TEN FOUNDING FATHERS OF THE ELECTRICAL SCIENCE

VIII. MICHAEL FARADAY

and the discovery of electromagnetic induction

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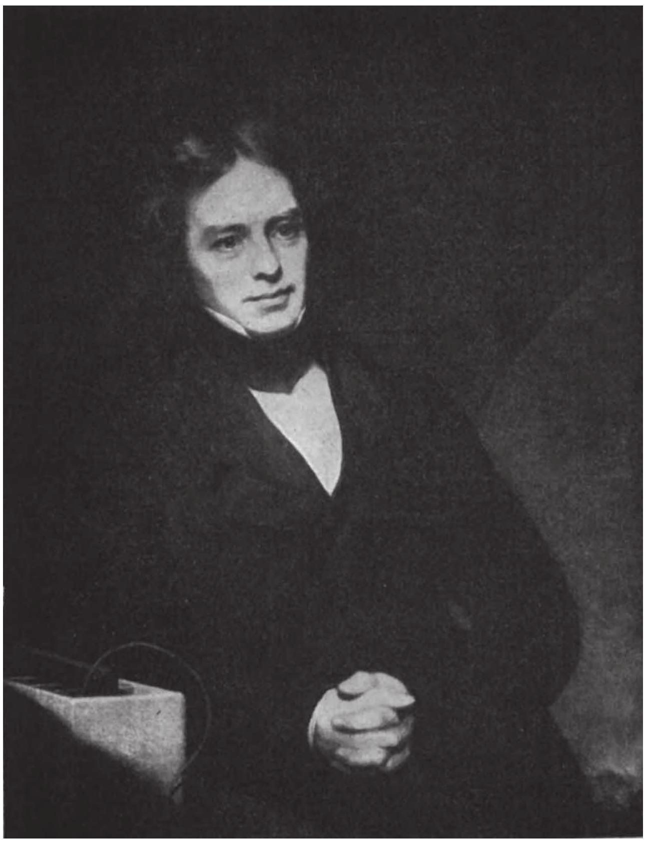
Michael Faraday was a chemist and electrical experimenter who discovered electromagnetic induction, the laws of electrolytic action and magnetic rotation. His discoveries led directly to large-scale electrification and electric controls in industry.

TWO STEPS advanced electrical science to the status of a major social force. The first was the invention by Alessandro Volta of a chemical source of electricity, the voltaic cell, and the second the discovery of electromagnetic induction by Faraday. Volta's battery provided early electricians with means for electrically decomposing elements, producing an electric arc, and more important, it led to the construction of the electromagnet which, in turn, opened the way to the full expansion of the electrical age.

The early investigators asked themselves why powerful magnets could be produced by the flow of an electric current in a wire, yet electricity could not be produced from a magnetic circuit. The problem set off many experiments in the first third of the 1800's. It remained for Michael Faraday to resolve this problem and thereby to transform the fabric of society into an ever-growing integrated network.



Michael Faraday

Of most humble origin, and with no formal education, Faraday began work at the Royal Institution in London as a laboratory assistant to Humphry Davy, an outstanding chemist and electrical experimenter of the time. Through Davy, Faraday met the important scientists of England and the Continent including Ampere, Count Rumford, and Volta. At the Royal Institution Faraday lived and experimented in chemistry and in electricity. A series of lectures and demonstrations before distinguished audiences, including royalty, brought the work of these experimenters before the rapidly expanding world of science.

Faraday's electrical experiments began to receive attention in 1821 when he demonstrated electromagnetic rotation, in which the flow of electric current caused a magnet to revolve around a wire carrying current or a wire carrying current to revolve around a fixed magnet. The motions continued as long as the current continued to flow. He then succeeded in causing a delicately balanced wire carrying current to move as a result of being in the earth's magnetic field alone. For 10 years thereafter, Faraday concerned himself with the problem of converting magnetic force into some form of electric force. He studied intensely what other experimenters had accomplished and, in particular, the phenomenon of electrostatic induction. Four times in these 10 years Faraday had applied himself to the specific investigation of magnetoelectric generation, with no results.

In the summer of 1831 he began a fifth attempt at solving the problem. He took a soft iron ring about 6 inches in diameter and wound a coil of copper wire on one side of the ring and a second coil on the other side. He next placed a magnetic needle a short distance from the ring and connected it to the first coil; a battery was connected to the second coil. At the instant of connection the magnetic needle moved and came to rest; when the connection was

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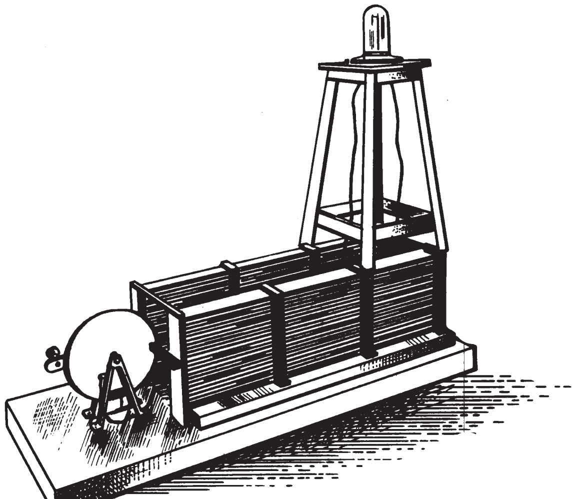
broken the motion was repeated in the opposite direction. He checked the true *magnetic* nature of the current produced by substituting a copper ring for the iron one and observed little motion. Faraday then wound a coil of 220 feet of wire into a solenoid and connected its ends to a galvanometer. When he plunged a cylindrical bar magnet into the coil, the needle moved; when he pulled it out, it moved in the opposite direction. He therefore concluded that it was the *relative* motion of magnet and coil that was inducing the generation of electric current.

Following the cue established by the momentary generation of an electric impulse from a magnetic source, on October 28, 1831, Faraday completed the assembly of an electric machine consisting of the great magnet of the Royal Society between the poles of which he had erected a copper disk 12 inches in diameter on an axle terminating in a crank. From the disk two collector strips were carried; one rode on the axle, the other on the rim of the disk, and these strips were led to a galvanometer. The axle and disk rim where the strips made contact were treated with amalgam. When Faraday revolved the disk by means of an attached handle the galvanometer showed a deflection; when he reversed the rotation the deflection was in the opposite direction. Faraday visualized his disk "cutting" magnetic lines flowing from pole to pole of the great magnet. These lines he could demonstrate by sprinkling iron filings in the path between pole and pole. When he replaced the disk by a wire that he moved across the magnetic field, the same results followed.



The generator with which Faraday converted magnetism into electricity

He devoted 10 days of intensive experimentation to check the nature of the electricity so produced and finally, at the end of November, announced his most important discovery before the Royal Society. Electricity finally had been produced from magnetism. This discovery was formulated into a paper for publication under the title "Experimental Researches in Electricity" and was the first of a series of 29 that continued on through 1852, announcing the many contributions of Faraday to the science he helped establish.

After Faraday's major contribution there came the discovery of self-induced currents, polarity in diamagnetic bodies, lines and fields of magnetic force, and the use of induced current as a measure of field intensity. In the work of his earlier interest, chemistry, he evolved the law of electrochemical decomposition, electrochemical conduction, analysis of generation in the voltaic pile, and the general theory of electrolysis. With his discoveries Faraday contributed a parallel vocabulary of new electrical and magnetic terms that have become the language of the science. His work carried him into a study of dielectrics and the determination of "specific inductive capacity." It was no easy step between the invention of the electric generator by the process of induction (which constitutes the practical form of the electric generators of today) and its practical use in industry. Devices to *use* this electricity still had to be invented. The electric light, the electric motor, metallurgical, thermal, or chemical use of electricity, these and similar devices awaited the inventive genius of later electricians. Other than its application to telegraphy it was not until 1860 that current from an electric generator was applied to lighthouse illumination thereby providing the first bulk use of the new force. However, from then on the science moved with increasing rapidity so that by the end of the century, in England alone, investments in electric equipment exceeded £100,000,000, a pyramid built up in less than 70 years.

Following the announcement of his discovery of the means for generating electricity by electromagnetic induction, in a paper read before the Royal Society on November 24, 1831, and in a letter to his friend Richard Phillips written from Brighton on November 25, the recognition of the importance of the discovery by scientists was immediate. Over a hundred academic and scientific honors were conferred upon Faraday, including the only one which he actively sought, membership in the Royal Society. Sponsored by Phillips, Faraday at the age of 32 became a Fellow of the Royal Society in January 1824. Appointed director of the laboratory of the Royal Institution in 1825, he became, 8 years later, professor of chemistry there for life. Although he was without the obligation to lecture, his lectures there became exceedingly popular. He remained at the Institution for 54 years and died in 1867.

In the 54 fruitful years he spent as experimenter and lecturer at the Royal Institution, Faraday had published 158 papers in chemistry and electricity. The most important of these was the series "Experimental Researches in Electricity" which continued to appear for a period of over 20 years. In the first of these, as he indicated in his announcement to Phillips, the title was established and the subjects treated were to be "I. On the induction of electric currents. II. On the evolution of Electricity from magnetism. III. On a New electrical condition of matter. IV. On Arago's magnetic phenomena. There is a bill of fare for you—." In January 1832 the first of these papers was published and in that year Oxford conferred an honorary doctorate on Faraday. A grateful International Electrical Congress, meeting in Paris in 1891, voted to term the electrical unit of capacitance the "farad" in honor of one who had contributed so much to electrical science.